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Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

1. Your reference	TRC/LP5721121
2. Patent application number *(The Patent Office will fill in this part)*	26OCT98 E399915-1 D00060 P01/7700 0.00 - 9823321.6
3. Full name, address and postcode of the or of each applicant *(underline all surnames)*	UNIVERSITY OF BRISTOL SENATE HOUSE TYNDALL AVENUE BRISTOL BS8 1TH
Patents ADP number *(if you know it)*	
If the applicant is a corporate body, give the country/state of its incorporation	GB 00798181001
4. Title of the invention	METHOD AND APPARATUS FOR TRADING USING AN ELECTRONIC COMMUNICATION NETWORK
5. Name of your agent *(if you have one)*	MEWBURN ELLIS
"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	YORK HOUSE 23 KINGSWAY LONDON WC2B 6HP
Patents ADP number *(if you know it)*	109006

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number	Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application	Date of filing
		23/10/1998

8. *Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	*YES*

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Continuation sheets of this form	0
Description	35
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11. *I/We request the grant of a patent on the basis of this application.*

Signature	*Date*
Mewburn Ellis	23 October 1998

12. *Name and daytime telephone number of person to contact in the United Kingdom* — TIMOTHY WATKIN — 0171 240 4405

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METHOD AND APPARATUS FOR TRADING USING AN ELECTRONIC COMMUNICATION NETWORK

The present invention relates to a method and apparatus for trading using an electronic communication network.

The phenomenal growth of the Internet and worldwide web in this last decade has been the driving force behind growth of electronic based trade and an explosion in electronic commerce (e-commerce) applications. Electronic commerce can be loosely defined as the process of trade which takes place through computer mediated electronic communication networks. Such systems can be further classified as "first generation" e-commerce systems, which are user-driven systems in which each user retains control of all trade related decisions, and "second generation" e-systems, in which each user delegates authority over some trade related decisions to an automatic agent (defined in software). Software agents interact using a "protocol", to further their users' interests.

e-commerce is only one example of a negotiation between self interested entities (human or software) which is carried out through computer mediated networks.

Second generation e-commerce systems are a special case of multi-agent systems (MAS). Multi-agent systems

can interact (once a protocol has been agreed) in an automated fashion. The use of multi-agent systems is known in the fields of industry, entertainment, patient care, health planning and finance, and such systems are described, for example, in the article "Applications of Intelligent Agents" by N.R. Jennings and M. Wooldridge (1997), available under electronic reference http:///www.springer.de/comp/special/jennings.pdf.

The principal feature of the agents is to be "self-interested", that is each of the agents acts in a way which maximises its (or its users) goals. For example, considering a commercial transaction in which a customer wishes to place a long-distance telephone call, the customer may employ a self-interested agent which interacts with various telephone providers (author agents) to obtain the cheapest telephone supply. Multi-agent systems composed of or including self-interested agents are vulnerable, in the sense that problems may arise which significantly reduce the efficiency of the trading.

Four examples of such vulnerability will now be given.

Firstly, consider an agent which represents a customer which wishes to buy a good. If the agent insists on obtaining a low price for the goods (because it is programmed to do so) but communicates only with

selling agents which are not allowed to negotiate prices, an impasse will be reached. The fruitless communications between the customer's agents and the selling agents use up network resources, and can thus significantly reduce the overall efficiency of the trading environment.

Secondly, consider the case of two agents programmed to schedule a meeting between their respective users. If the two users have conflicting requirements concerning the time or place of the meeting, then a negotiation between the scheduling agents will be fruitless. If neither agent is willing to make a concession, then an impasse is reached, and the communication has consumed network resources to no purpose.

Thirdly, consider an on-line auction. In this case, the efficiency of the trading is determined, among other factors, by the revenue which is generated for the sellers. A variety of protocol types can be identified, such as so called "English auctions" or "first-price sealed-bid" auctions. The revenue generated generally depends on the type of protocol, but which protocol type maximises efficiency can depend on the characteristics of the auction (for example on whether the goods being sold can be re-sold). If the sellers and buyers have a mis-matched understanding of this underlying structure, then the auction is unlikely to be efficient.

Fourthly, consider a market for goods such as electronic components. Conventionally in such a market both sellers and buyers post prices and trade takes place when those prices match. What constitutes optimal behaviour for the trading agents depends on the ratio between the quantity of goods demanded and the quantity supplied. Specifically, if only one agent is selling a certain component and many agents demand that component, then the seller can expect to extract much of the surplus for itself. On the other hand, if supply greatly exceeds demand, the buyer should be able to extract most of the surplus. Thus, if the agents of the sellers and buyers are not sensitive to the ratio of supply and demand, their expectations may mis-match and impasses of the kind described above may occur.

A very important feature of multi-agent systems is that there is no control over the behaviour of individual agents, except through the protocol. Currently because of the risk of inefficiencies, these systems maintain the option of intervening and dictating agreements. This is highly undesirable (since it goes against the main motivation for using MAS). Also, in the long run agents can learn to anticipate that the system will intervene, and change their behaviour accordingly, causing even more inefficiency. For example, a party which believes it will be better off if the system intervenes will

deliberately make negotiations inefficient to ensure intervention by the system.

The present invention seeks to provide a new and useful method and apparatus for trading using an electronic communication network.

This invention provides regulation for automated negotiation by comparing hypotheses (based on available information) about the negotiating environment with observed negotiating behaviour and/or outcomes.

In a first aspect, the invention provides a method of regulating negotiation between two or more negotiating parties which communicate using an electronic communication network, the method employing a set of negotiating parameters including one or more hypotheses concerning a negotiating environment, and including the steps of:

for each of said one or more hypotheses deriving a respective numerical confidence value, the or each confidence value representing confidence in the truth of the respective hypothesis; and

regulating communication between said negotiating parties using said electronic communication network, based on said one or more confidence values.

Preferably, the method includes at least once performing the additional step of re-evaluating said one or more confidence values based on characteristics of

said negotiation.

The method may be carried out, for example, to influence the protocol, or even as part of the protocol.

The negotiating environment may be any situation in which more than one party negotiates such as a commercial situation in which one or more suppliers trade to supply one or more goods or services to one of more buyers (e-commerce). It also includes negotiations which are not specifically concerning the supply of goods or services, such as a negotiation concerning timings for a meeting.

The negotiating parameters represent a classification based on underlying strategic strategy. For humans, the "laws of the game" are mostly clear, and even if humans negotiate inefficiently because they do not understand these rules this can be indicated to them. The present invention permits a technology which tells automated agents that they are wrong (they are using an inappropriate frame work). For example, if the negotiation proceeds in a way which is inconsistent with the hypotheses, a party can identify that the hypotheses are incorrect. For example, a party may identify parameters (either among the negotiating parameters, or derived from them), which are expected to reach constant values during negotiation. If this is not achieved, the party can identify that the hypotheses are incorrect.

Preferably, the method includes a step (e.g. off-

line before the on-line negotiation) of deriving the set of negotiating parameters in a way appropriate to the negotiating environment. This may include selecting the one or more hypotheses, to which confidence values are then assigned.

Preferably, in addition to re-evaluation of the confidence value(s), the method includes a step (for example carried out in predefined circumstances) of re-evaluating the set of hypotheses itself, followed by a redefinition of confidence values for the new set of hypotheses. Thus, for example, if during the negotiating method the user of the method discovers an inconsistency between the confidence values and some new piece of information, the method may include re-evaluating the set of hypotheses to overcome the inconsistency.

Usually (though not necessarily), the re-evaluation of the set of hypotheses will increase the number of hypotheses, but the method still preferably minimises the number of hypotheses in relation to the available data.

The updating and hypothesis setting is preferably based only on data which is relevant. That is, the invention is not only "asking questions and forming hypotheses", but also "asking the *right* questions". Moreover, the set of hypotheses (not just the distribution of confidence values) is a representation of the underlying strategic structure.

Preferably, the one or more hypotheses concern one or more of (i) characteristics of the bargaining power of one or more further negotiating parties and (ii) characteristics of agents involved in the negotiation (e.g. based on past experience). If applicable, the hypotheses are also preferably defined based on types of goods or services being traded.

Preferably, the method further including a step of normalising the confidence values. For example, in the case that the hypotheses are mutually contradictory, the normalising step may include adjusting them so that their total value adds up to 1.

The hypotheses may fall into a number of groups. For example, one group of hypotheses may relate to the total number of negotiating parties (e.g. a first hypothesis that there is one other negotiating party, a second hypothesis that there are two, and a third hypothesis that there are more than two), while a second group of hypotheses may relate to the average size of other negotiating parties. In this case, a normalization step may involve normalizing the confidence values of the hypotheses of one or more of these groups.

In addition to the hypotheses, the negotiating parameters may further include additional parameters which characterize the negotiation process. For example, one such additional parameter may be whether the method

is used for buying or for selling. The additional parameters may be in terms of numerical characterization variables. In this case, the method may include a step of setting the characterization variables (e.g. in the case of a selling process, the method may include a step of setting a characterization variable which represents the fact that method is selling, to "1"). The characterization parameters themselves may optionally be changed, if a party fundamentally reassesses the negotiating environment.

If a low-efficiency condition is identified, the method may include alerting one or more of the users to this fact, and preferably triggering a re-evaluation of the hypotheses and/or confidence values.

Accordingly, in a second aspect, the invention provides a method of regulating a negotiation using an electronic communication network, in which a plurality of negotiating parties negotiate regulated by a set of negotiating parameters including one or more hypotheses, the method including identifying, by comparing the actual negotiation to the negotiating parameters, a characteristic of the negotiation.

For example, the characteristic may by the liability of the negotiation to inefficiency (in time and/or revenue generated).

In further aspects, the invention provides

apparatus for performing the methods of the invention. For example, the invention provides an apparatus adapted to regulate negotiation using negotiating parameters and identifying one or more characteristics of the negotiation. For example, there may be only one characteristic, namely the liability of the negotiation to become inefficient.

In a further aspect, the invention provides a computer-readable electronic data carrier carrying a program for performing one of the methods described above.

Examples of the invention will now be described for the sake of example only.

Fig.1 shows an embodiment of the present invention.

A plurality of agents (labelled 1,..,N) interact via a protocol. The protocol is determined, or at least influenced, by numerical outputs of the inventive system described below.

General Description of Examples

In all three examples, S is the set of all possible states (including hypotheses, and optionally also additional parameters characterizing the negotiation). The set of confidence values (and characterization

variables for the additional parameters) are here represented by a set P (there is a value of P for each of the hypotheses in S). The off-line algorithm initiates P. We can then define $S'=\{s \in S; p(s) > 0\}$, i.e. S′ is the set of all states which have a positive probability.

We then define another set, T (which we will expect to attain equilibrium behaviour and outcomes during negotiation according to the methods of the invention). The set T is normally much smaller than S. For each parameter in S, there is at least one link to a state in T, which carries a certain weight on it. This represents a likely causal relationship. For example, in a double auction j="No" (no big player present), is linked to the state "Competitive outcome" in T with a large probability.

Because the number of states in T is smaller than S, most states in T have several links leading to them from different states. This creates a relationship between states in S, which is based on the similarity of the equilibrium outcomes.

Once P is set (and at any given stage after P is updated):

(1) The probability of an individual state is given by the product of the probabilities in each of the categories.

(2) The probability of a set of state is equal to the sum of the probabilities of the individual states in that set.

(3) The probability of the states in T is obtained in the following way: For each state, T′ in T, we compute cp(T′) - the sum of the probabilities of the states in S which link to this state, multiplied by the weights of these links. We then define the probability of state T′ as

$$p(T') = \frac{cp(T')}{\sum_{T' \in T} cp(T')}.$$

Therefore, after each iteration (i.e. updating of the p values) the system has a probability distribution over the outcomes and equilibrium behaviour it expects to observe.

There are two types of updating procedures:

Updating parameters based on new information (the value of some of the parameters which are "on-line" will become known, for example the number of bidders). This should be a straightforward updating of P (and therefore of S′).

Updating based on observed equilibrium outcome or behaviour (this is not directly done by the system. The protocol can inform the system that certain behaviour is observed. The system, however, responds to such input by

the following procedure). Here, we work backwards, and update all the states in S which link to the state in T which is now being updated. This could be negative (i.e. a state in T has a higher weight than observed) or positive (i.e. a state in T has a lower probability from what is observed. On the extreme, a state which currently has zero probability had occurred).

The first type of updating, (normally) updates the P values associated with the states in S'. It cannot enlarge S', but could, in some cases make it smaller by setting the probability of one or more of the states in S' to zero.

The second type of updating (and sometimes also the first, although this would mean that the wrong data was given off-line), can lead to updating S' itself, by recognising that a state (or a set of states), which is not included in S' (i.e. not anticipated by the system) is now likely.

Throughout the off-line setting of P, if a "don't know" answer is given, it is possible to include a procedure which investigates the matter further by case-base matching (for example, if a "don't know" answer is given for the value of the good traded, then we can use the fact that all kinds of consumption goods, like foods, are private value and so on).

More specifically, the updating procedure is as

follows:-

1. At the end of the off-line stage, the protocol (user) receives a set of states, S; a probability distribution P over that set; a set T; and a probability distribution p(T) over the set T.
2. New information about P may become available to the protocol at the on-line stage (for example, the number of bidders may have been unknown in advance, but becomes known on-line). The protocol can transmit this new information to the invention, which in turn updates P and p(T) accordingly.
3. The above described new information is transmitted by the protocol (user) to the invention (system) in the form of new numerical values, the v's or w's, describing the probabilities of certain parameters (e.g. new probabilities for the number of bidders).
4. In addition to new information about P, the protocol can transmit to the invention updated information regarding observed negotiating behaviours and/or observed outcomes of negotiations, i.e. information regarding p(T).
5. This new information about p(T) can be used by the invention for backward updating of P and p(T) (as described below).
6. Once again, the above described new information is transmitted by the protocol to the invention using

numerical values (either v's or w's) describing the observed likelihoods of states in T.

7. Both the v's and the w's serve the same purpose: transmitting new information to the invention. The main difference between the two is the following:

a) The protocol (user) may wish to completely re-write existing values in P (or p(T)), for example if the protocol learns that the number of bidders in the on-line auction is, say, 6, then it can set P(j="4-10")=1 hence overwriting any existing values for j. In this case the protocol uses the V's.

b) The protocol may wish to <u>update</u> existing values, rather than replace (this is likely when continuous and gradual updating takes place. It is also the more 'natural' way to update p(T)). In this case the protocol uses the w's ("w" for "weight"), which are then used by the invention as weights for updating existing values in p, or in p(T) (as explained below)

Example 1: Double auction

A double auction is a marketplace where sellers and buyers post demand and supply functions (for example, "willing to buy 7 units at price", "selling at X per unit

up to 20 units, and Y per unit for 20 or more").

(1) States of the world: $S(i, j, k, l, m, n) = 5\times2\times3\times2\times4\times2 = 480$ states, in a six dimensional array.

Parameters:

i: Ratio of buyers to sellers, 5 states: 1 to 1, 1 to 2 or more, ratio smaller than one third, ratio between one and two thirds, ratio greater than two thirds.

j: Presence of "big" players, 2 states: Yes, No.

k: Value of object or service, 3 states: Private value, common value, correlated value.

l: Repeated interactions, 2 states: Yes, No (or not significant)

m: Outside option, 4 states: Yes for all, Only for Sellers, Only for buyers, No for all.

n: Capacity constraints, 2 states: Significant, Not significant.

The set T:

T1: Symmetry between buyers and sellers

T2: Asymmetric - buyer side more competitive

T3: Asymmetric - sellers side more competitive

T4: Competitive outcome expected

T5: Non-competitive outcome expected

T6: Reputation and history dependent strategies likely

(2) Initiating P: Through off-line algorithm below.

Question: Enter the estimated number of buyers and sellers (the program then computes A=abs(#sellers minus #buyers)/max(#sellers, #buyers)

Answer: 1 to 1 Action: Set p(i="1-1")=1

Answer: 1 to 2+ Action: Set p(i="1-2+")=1

Answer: A<1/3 Action: Set p(i="<1/3")=1

Answer: 1/3<A<2/3 Action: Set p(i="1/3<2/3")=1

Answer: A>2/3 Action: Set p(i=">2/3")=1

Answer: Don't know Action: Set 5*p(i="1-1")=3*p(i="1-2+")= p(i="<1/3")=2*p(i="1/3<2/3")=2*p(i=">2/3")

Answer: Manual Action: Set i.

Answer: On-line Action: Set 5*p(i="1-1")=3*p(i="1-2+")= p(i="<1/3")=2*p(i="1/3<2/3")=2*p(i=">2/3")

Set On-line=On-line ∪ {i}

Question: Are there "big" players present?

Answer: Yes Action: Set p(j="Yes")=1

Answer: No Action: Set p(j="No")=1

Answer: Don't know Action: Set 2*p(j="No")=p(j="Yes")

Answer: Manual Action: Set j.

Question: What is the value of the object or service traded?

Answer: Private Action: Set p(k="Private")=1

Answer: Common Action: Set p(k="Common")=1

Answer: Correlated Action: Set p(k="Correlated")=1

Answer: Don't know Action: Set p(k="Private")=10*p(k="Common")= 10/9*p(k="Correlated")

Answer: Manual Action: Set k.

Answer: On-line Action: Set p(k="Private")=10*p(k="Common")= 10/9*p(k="Correlated")

Set On-line=On-line ∪ {k}

Question: Repeated Interaction?

Answer: Yes Action: Set p(l="Yes")=1

Answer: No Action: Set p(l="No")=1

Answer: Don't know Action: Set 4*p(l="No")=p(l="Yes")

Answer: Manual Action: Set l.

Question: Outside option?

Answer: Yes to all Action: Set p(m="YAll")=1

Answer: Sellers only Action: Set p(m="Sellers")=1

Answer: Buyers only Action: Set p(m="Buyers")=1

Answer: No to all Action: Set p(m="NAll")=1

Answer: Don't know Action: Set p(m="Yall")=3*p(m="Sellers")= 3*p(m="Buyers")=p(m="NAll").

Answer: Manual Action: Set m.

Answer: On-line	Action: Set p(m="Yall")=3*p(m="Sellers")= 3*p(m="Buyers")=p(m="NAll"). Set On-line=On-line ∪ {m}

Question: Capacity constraints?

Answer: Significant	Action: Set p(n="Sign")=1
Answer: Not significant	Action: Set p(n="No")=1
Answer: Don't know	Action: Set p(n="Sign")=p(n="No")
Answer: Manual	Action: Set n.
Answer: On-line	Action: Set p(n="Sign")=p(n="No") Set On-line=On-line ∪ {n}

Stage 2: Set the following links:

FROM: i="1-1"	TO: T1	WEIGHT: 0.5
FROM: i="1-1"	TO: T4	WEIGHT: 1
FROM: i="1-2+"	TO: T2	WEIGHT: 0.8
FROM: i="1-2+"	TO: T3	WEIGHT: 0.8
FROM: i="<1/3"	TO: T1	WEIGHT: 0.8
FROM: i="<1/3"	TO: T4	WEIGHT: 0.9
FROM: i="1/3<2/3"	TO: T2	WEIGHT: 0.5
FROM: i="1/3<2/3"	TO: T3	WEIGHT: 0.5
FROM: i="1/3<2/3"	TO: T4	WEIGHT: 0.5

FROM: i=">2/3"	TO: T2	WEIGHT: 0.9
FROM: i=">2/3"	TO: T3	WEIGHT: 0.9
FROM: i=">2/3"	TO: T5	WEIGHT: 0.9
FROM: j="Yes"	TO: T5	WEIGHT: 0.8
FROM: j="Yes"	TO: T6	WEIGHT: 0.8
FROM: j="No"	TO: T4	WEIGHT: 0.5
FROM: k="Private"	TO: T4	WEIGHT: 0.7
FROM: k="Common"	TO: T5	WEIGHT: 0.8
FROM: k="Correlated"	TO: T5	WEIGHT: 0.6
FROM: l="Yes"	TO: T5	WEIGHT: 0.8
FROM: l="Yes"	TO: T6	WEIGHT: 1
FROM: l="No"	TO: T4	WEIGHT: 0.5
FROM: m="YAll"	TO: T1	WEIGHT: 0.7
FROM: m="Buyers"	TO: T3	WEIGHT: 0.9
FROM: m="Sellers"	TO: T2	WEIGHT: 0.9
FROM: m="NAll"	TO: T1	WEIGHT: 0.5
FROM: m="NAll"	TO: T4	WEIGHT: 0.6
FROM: n="Yes"	TO: T5	WEIGHT: 0.8
FROM: n="No"	TO: T4	WEIGHT: 0.5

(3) Updating rules:

Type I:

These will be described later.

Type II:

These will be described later.

Example 2: Scheduling (one-to-one negotiations)

(1) States of the world: S(i,j,k,l,m) = 3×3×2×2×3=108 states, in a four dimensional array.

Parameters:

i: Outside option, 3 states: none/one of the players/both players.

j: Deadlines, 3 states: none/ one of the players/both players.

k: Patience attitudes, 2 states: significant differences/no significant difference.

l: Repeated interactions, 2 states: yes/no.

m: Strategic complimentarities, 3 states: no conflict/some conflict/opposite preferences.

The set T:

T1: Extreme ex-ante asymmetry (no bargaining)

T2: Ex-ante asymmetry (both sides have some bargaining power)

T3: Symmetric ex ante bargaining

T4: Value of surplus compared to value of deal significant

T5: Value of surplus compared to value of deal not significant

T6: Reputation and history dependent strategies likely

(2) Initiating P: Through off-line algorithm below.

<u>Question</u>: Outside option?

<u>Answer</u>: None	<u>Action</u>: Set p(i="None")=1
<u>Answer</u>: One of the players	<u>Action</u>: Set p(i="OneSide")=1
<u>Answer</u>: Both players	<u>Action</u>: Set p(i="Both")=1
<u>Answer</u>: Don't know	<u>Action</u>: Set p(i="None")=p(i="OneSide")=p(i="Both")
<u>Answer</u>: Manual	<u>Action</u>: Set i.
<u>Answer</u>: On-line	<u>Action</u>: Set p(i="None")=p(i="OneSide")=p(i="Both") Set On-line=On-line $\cup$ {i}

<u>Question</u>: Deadlines?

<u>Answer</u>: None	<u>Action</u>: Set p(j="None")=1
<u>Answer</u>: One of the players	<u>Action</u>: Set p(j="OneSide")=1
<u>Answer</u>: Both players	<u>Action</u>: Set p(j="Both")=1
<u>Answer</u>: Don't know	<u>Action</u>: Set p(j="None")=3*p(j="OneSide") =3*p(j="Both")
<u>Answer</u>: Manual	<u>Action</u>: Set j.
<u>Answer</u>: On-line	<u>Action</u>: Set p(j="None")=p(j="OneSide")=p(j="Both") Set On-line=On-line $\cup$ {j}

Question: Patience attitude of bargaining parties?

Answer: Significant difference — Action: Set p(k="Sign")=1

Answer: No significant difference — Action: Set p(k="No")=1

Answer: Don't know — Action: Set p(k="No")=3*p(k="Sign")

Answer: Manual — Action: Set k.

Answer: On-line — Action: Set p(k="No")=3*p(k="Sign")

Set On-line=On-line $\cup$ {k}

Question: Repeated interactions?

Answer: Yes — Action: Set p(l="Yes")=1

Answer: No — Action: Set p(l="No")=1

Answer: Don't know — Action: Set 4*p(l="No")=p(l="Yes")

Answer: Manual — Action: Set l.

Question: Strategic complimentarities?

Answer: No conflict — Action: Set p(m="NoConf")=1

Answer: Some conflict — Action: Set p(m="Mix")=1

Answer: Opposit preferences — Action: Set p(m="Opp")=1

Answer: Don't know — Action: Set p(m="NoConf")=p(m="Mix")=p(m="Opp")

Answer: Manual — Action: Set m.

Answer: On-line — Action: Set p(m="NoConf")=p(m="Mix")=p(m="Opp")

Set On-line=On-line $\cup$ {m}

Stage 2: Set the following links:

FROM: i="None"	TO: T3	WEIGHT: 0.8
FROM: i="OneSide"	TO: T1	WEIGHT: 0.2
FROM: i="OneSide"	TO: T2	WEIGHT: 0.5
FROM: i="Both"	TO: T3	WEIGHT: 0.8
FROM: j="None"	TO: T3	WEIGHT: 0.8
FROM: j="OneSide"	TO: T1	WEIGHT: 0.2
FROM: j="OneSide"	TO: T2	WEIGHT: 0.5
FROM: j="Both"	TO: T3	WEIGHT: 0.8
FROM: k="No"	TO: T3	WEIGHT: 0.8
FROM: k="Sign"	TO: T1	WEIGHT: 0.2
FROM: k="Sign"	TO: T2	WEIGHT: 0.5
FROM: l="Yes"	TO: T6	WEIGHT: 0.8
FROM: m="NoConf"	TO: T5	WEIGHT: 1
FROM: m="Some"	TO: T4	WEIGHT: 0.2
FROM: m="Some"	TO: T5	WEIGHT: 0.2
FROM: m="Opp"	TO: T4	WEIGHT: 1

(3) Updating rules:

Type I:

These will be described later.

Type II:

These will be described later.

Example 3: On-line auction houses

An on-line auction is a situation where one seller (or buyer), sells (or buys) a good or service through an auction protocol, to 2 or more potential buyers (sellers).

Auctions are among the simplest cases of a trading environment because there are only a relatively small number of factors which influence the underlying incentive structure of participating agents.

(1) Defining states of the world

To set up the example we consider a model of the world (the trading environment) in which the states of the world are given by a seven dimensional array S(i, j, k, l, m, n, o, p). Addressing these variables in turn,

-Index i (which has two states) represents whether the method is used for buying or selling?

-Index j represents the number of other parties (buyers or sellers)? Index j is an integer which can take 5 values(representing whether the number of players is 2, 3, 4-10, 11-20, or 21 or more).

-Index k represents whether there big players, or only small? Thus, k has 2 states.

-Index l represents whether an object or a service is being traded. It thus has 2 states.

-Index m has 3 states and labels whether the goods are single unit, multi-unit sold sequentially or multi-unit sold simultaneously?

-Index n represents whether value is private value, common value, or correlated value? It has 3 states.

-Index o represents whether trading is made up of repeated interactions (in a way that matters). Index n has 2 states.

-Index p represents whether there is a outside option (e.g. competition between auctions) It has 2 states: Yes, No (or not significant).

Thus there are 2x5x2x2x3x3x2x2 = 1440 possible world states.

Set T:

T1: Competitive environment

T2: Non-competitive environment

T3: Surplus extraction possible

```
T4: Reputation and history dependent strategies likely.
```

(2) **Initiating P**: Through off-line algorithm below.

Question: Buying or Selling?

Answer: Buying	Action: Set p(i="Buying")=1
Answer: Selling	Action: Set p(i="Selling")=1
Answer: Manual	Action: Set i.
Answer: On-line	Action: Set p(i="buying")=p(i="selling") Set On-line=On-line $\cup$ {i}

Question: Number of bidders 2,3,4-10,11-20,more than 20?

Answer: 2	Action: Set p(j="2")=1
Answer: 3	Action: Set p(j="3")=1
Answer: 4-10	Action: Set p(j="4-10")=1
Answer: 11-20	Action: Set p(j="11-20")=1
Answer: 20+	Action: Set p(j="20+")=1
Answer: Manual	Action: Set j.
Answer: On-line	Action: Set p(j="2")=p(j="3")=p(j="4-10")=p(j="11-20")=p(j="20+") Set On-line=On-line $\cup$ {j}
Answer: Don't know	Action: Set p(j="2")=p(j="3")=p(j="4-10")=p(j="11-

20")=p(j="20+")

Question: Are there big players present?

Answer: Yes Action: Set p(k="No")=0

Answer: No Action: Set p(k="Yes")=0

Answer: Don't know Action: Set 5*p(k="Yes")=p(k="No")

Question: Object or Service?

Answer: Object Action: Set p(l="Service")=0

Answer: Service Action: Set p(l="Object")=0

Answer: Manual Action: Set j.

Answer: On-line Action: Set p(l="Service")=p(l="Object")

Set On-line=On-line ∪ {l}

Question: Single unit, multi-unit sold simultaneously, multi-unit sold sequentially?

Answer: Single Action: Set p(m="Single")=1

Answer: Multi-sim Action: Set p(m="Multi-sim")=1

Answer: Multi-seq Action: Set p(m="Multi-seq")=1

Answer: Manual Action: Set m.

Answer: On-line Action: Set p(m="Single")= p(m="Multi-sim")= p(m="Multi-seq")

Set On-line=On-line ∪ {m}

Question: Private, common or correlated value?

Answer: Private Action: Set p(n="Private")=1

Answer: Common Action: Set p(n="Common")=1

Answer: Correlated Action: Set p(n="Correlated")=1

Answer: Manual Action: Set n.

Answer: Don't know Action: Set p(n="Private")=10*p(n="Common")= 10/9*p(n="Correlated")

Answer: On-line Action: Set p(n="Private")=10*p(n="Common")= 10/9*p(n="Correlated")

Set On-line=On-line ∪ {n}

Question: Repeated game?

Answer: Yes Action: Set p(o="No")=0

Answer: No Action: Set p(o="Yes")=0

Answer: Manual Action: Set o.

Answer: Don't know Action: Set p(o="No")=10*p(o="Yes")

Question: Competition with other auction sites?

Answer: Significant Action: Set p(p= "No")=0

Answer: Not sig. Action: Set p(p="Yes")=0

Answer: Manual Action: Set p.

Answer: Don't know Action: Set p(p="No")=p(p="Yes")

Stage 2: Set the following links:

FROM: j="2"	TO: T2	WEIGHT: 1
FROM: j="3"	TO: T2	WEIGHT: 0.8
FROM: j="4-10"	TO: T2	WEIGHT: 0.5
FROM: j="4-10"	TO: T1	WEIGHT: 0.5
FROM: j="11-20"	TO: T1	WEIGHT: 0.8
FROM: j="11-20"	TO: T3	WEIGHT: 0.5
FROM: j="20+"	TO: T1	WEIGHT: 1
FROM: j="20+"	TO: T3	WEIGHT: 0.8

FROM: k="Yes"	TO: T2	WEIGHT: 0.6
FROM: k="Yes"	TO: T4	WEIGHT: 1
FROM: k="No"	TO: T1	WEIGHT: 0.7
FROM: k="No"	TO: T3	WEIGHT: 0.4

FROM: n="Private"	TO: T1	WEIGHT: 0.7
FROM: n="Common"	TO: T2	WEIGHT: 0.8
FROM: n="Correlated"	TO: T2	WEIGHT: 0.6

FROM: o="Yes"	TO: T2	WEIGHT: 0.6
FROM: o="Yes"	TO: T4	WEIGHT: 1
FROM: o="No"	TO: T1	WEIGHT: 0.7
FROM: o="No"	TO: T3	WEIGHT: 0.4

FROM: p="Yes"	TO: T1	WEIGHT: 0.8

FROM: p="No" TO: T2 WEIGHT: 0.1

FROM: p="No" TO: T3 WEIGHT: 0.6

(3) Updating rules:

Type I:

See later

Type II:

See later

Updating

Two methods which may be employed for updating the p values (i.e. type 1 updating) in the examples above, will now be explained.

Note that the user referred to in the following two examples is not one of the negotiating parties, but rather the protocol itself (i.e. the system which mediates between the negotiating parties).

Method I: Forward on-line updating

For each parameter in the set {On-line} the system invites the user to input values on-line. (In addition,

the user can at any stage, update the value associated with any of the parameters).

The following procedures is applied when a parameter, say j, is being updated On-line:

Denote by j1, j2, ...jN the possible values of parameter j (for example: for the parameter "number of bidders" in example 3 there are five possible values: "2", "3", "4-10", "11-20", and "20+").

The system asks the user whether the old values should be overwritten or updated (note that at the on-line stage all parameters have been assigned initial values):

If overwritten:

(1)User enters new values v(j1), v(j2), ...v(jN), which satisfy v(ji)$\geq$0 for all i=1, ...N. At least one of these values is strictly positive and $\sum_{i=1,..,N} v(ji) < 1.$

(2)For all v(ji)=0, set:

$$p^{new}(j="ji") = \left(1 - \sum_{i\in 1,..,N \text{ and } v(ji)=0} v(ji)\right) \frac{p^{old}(j="ji")}{\sum_{i\in 1,..,N \text{ and } v(ji)=0} p^{old}(j="ji"')}$$

If updated:

(1)User enters updating weights w(j1), w(j2), ... w(jN). At least one of which is different from zero.

(2)Set p'(j=i"ji")=p(j="ji")+w(ji)for j=1, ...N

(3) Set

$$p(j = "ji") = \frac{p'(j = "ji")}{\sum_{i=1,\ldots,N} p'(j = "ji"')}$$

Method II: Backward On-line updating.

The following procedures is applied when the probability of one of more of the states in T is being updated On-line:

Denote by T1, T2, ... TN the possible states in T.

STAGE I

As in the forward updating procedures, the system asks the user whether the old values should be overwritten or updated:

(1) User enters new values v(T1), v(T2), ... v(TN), which must satisfy v(Ti)$\geq$0 for all i+1, ...N. At least one of these values is strictly positive, and $\sum_{i=1,\ldots,N} v(Ti) < 1.$

(2) For all v(Ti)=0, set:

$$p^{new}(Ti) = \left(1 - \sum_{i \in 1,\ldots,N \text{ and } v(Ti)=0} v(Ti)\right) \frac{p^{old}(Ti)}{\sum_{i \in 1,\ldots,N \text{ and } v(Ti)=0} p^{old}(Ti)}$$

If updated:

(1) User enters updating weights w(T1), w(T2), ... w(TN).

At least one of which is different from zero.

(2) Set p'(Ti)=p(Ti)+W(Ti) for i=1 ...., N

(3) Set

$$p(Ti) = \frac{p'(Ti)}{\sum_{i=1,\dots,N} p'(Ti)}.$$

STAGE 2

For each state Ti such that p(Ti) had changed, find all links which lead to it (for example, for T1 in example 1, there are 4 links which lead to it: from m="YAll", from m="NAll", from i="1-1" and from 1=",1/3").

Denote these links by Li1, Li2, ... LiN and by P(Lij) the specific value that this link leads from, and by (V(Lij) the specific value of that parameter which triggers the link (for example, for the link from m="NAll" to T1, P(L1j) is m, and V(L1j) is "NAll"). Finally, denote by S(Lij) the weight associated with the link Lij.

(1) Set:

$$p'(V(Lij) = P(Lij)) = \left(p^{old}(Ti) - p^{new}(Ti)\right).\frac{S(Lij)}{\sum_{j=1..N} S(Lij)}.p(V(Lij) = P(Lij))$$

(2) Normalise the probabilities:

For each parameter for which the above probability of at least one of the possible outcomes had changed as a result of the above calculations, the following normalising procedure will be carried out:

Denote the parameter by j, and the possible outcomes as j1, j2 ... jN.

Set

$$p(j="ji")=\frac{p'(j="ji")}{\sum_{i=1,\ldots,N} p'(j="ji"')}.$$

Important: If all links lead to event which have zero probabilities the above calculations will not work (division by zero).This implies that an event with zero probability now becomes likely (or even already occurred). In this case, the set S' and the probabilities P need to be re-computed, by informing the user and re-doing the appropriate off-line algorithm.

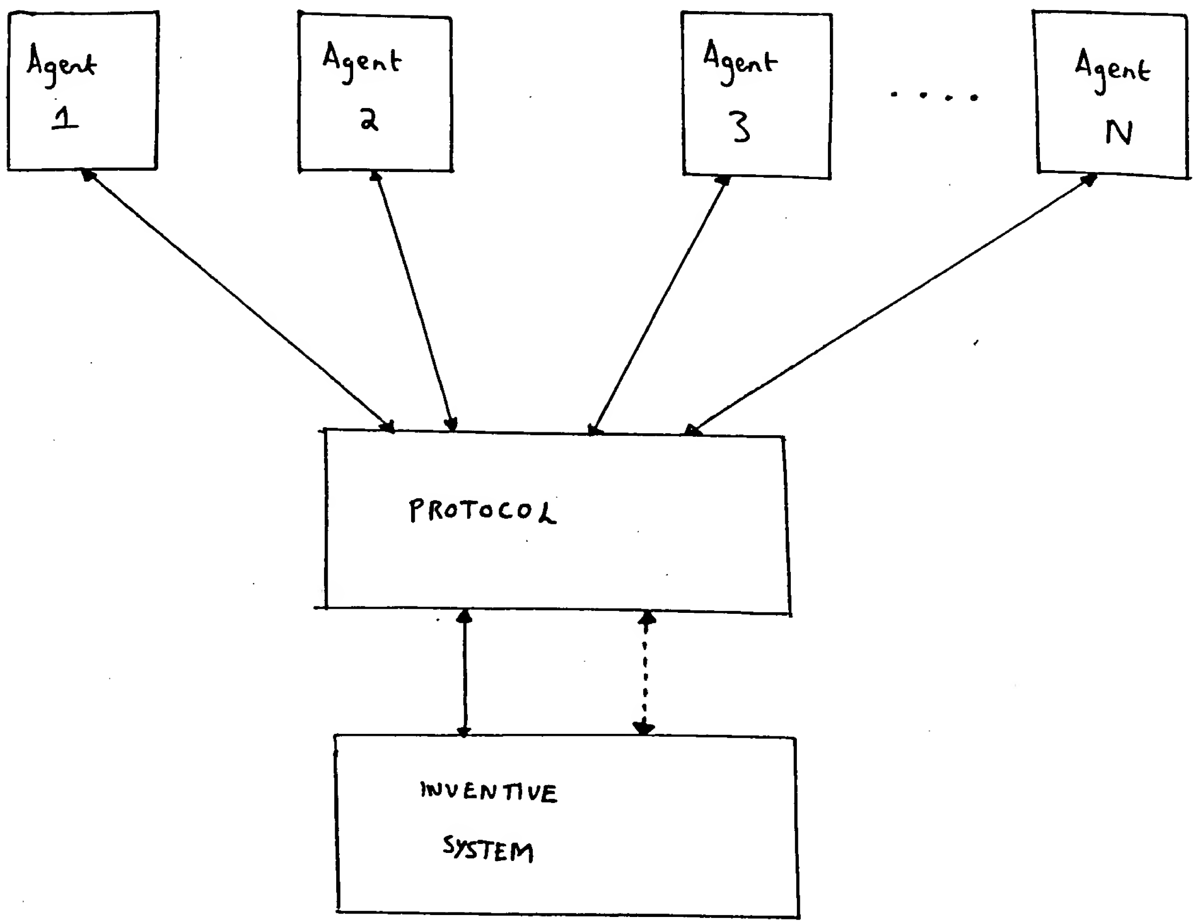
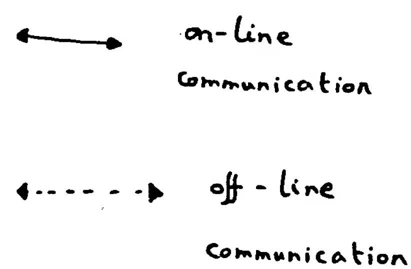

Agent 1
Agent 2
Agent 3
....
Agent N
PROTOCOL
INVENTIVE SYSTEM

Fig. 1


on-line communication
off-line communication

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